International Journal of Environment and Resource Volume 3 Issue 2, May 2014 www.ij-er.org
doi: 10.14355/ijer.2014.0302.02

Dynamic Analysis of The Hollow Jet Valve Operation For Eutrophication Control in Jatiluhur Tropical-Riverine Reservoir, Indonesia

Eko W. Irianto*[1], R. W. Triweko[2], P. Soedjono[3]

[1]PhD Student on Water Resources Engineering, Parahyangan Catholic University, Bandung, Indonesia.

[2]Professor on Water Resources Engineering, Parahyangan Catholic University, Bandung, Indonesia.

[3]Environmental Engineering Department, Institute of Technology Bandung, Bandung, Indonesia.

[1]ekowinar@yahoo.com; [2]triweko@unpar.ac.id; [3]psudjono@comices.org

Received 5 September 2013; Accepted 8 November 2013; Published 15 May 2014

Abstract

The efforts for eutrophication control have been conducted in many countries, i.e. physics, chemicals and biology. One of the alternatives is hypolimnetic withdrawal technique using *hollow jet valve* (HJV). So, the research objective is the application of dynamic numerical model to analyze the affect of HJV to reduce organics and nutrients pollutants in Jatiluhur tropical-riverine reservoir, Indonesia. Research methods are as follow: (1) data collections; (2) analysis of bathymetric maps; (3) dynamic numerical analysis using box volume model, assisted by WASP, and (4) calibration and simulation analyses. Results of numerical analysis shows that HJV operation operated in at 50 m^3/s, 24 hours every month along 8 years can improve the DO, BOD, TN and TP and chlorophyll-a mainly in lacustrine zone, at Jatiluhur Reservoir. Integration programs between HJV operation and pollutant sources reduction emitted by fish-cages cultured,until 99% compared with existing condition can restore Jatiluhur Reservoir from hypereutrofic to oligotrofic statues, i.e. 3 mg/l O_2; less than 0,5 mg/l BOD; 0,6 mg/l of TN; 0,05 mg/l of TP and less than 10 μg/l of Chlorophyll-a.

Keywords

Eutrophication; WASP; Jatiluhur Reservoir; Box Volume Model; Lacustrine Zone; Dynamic Analysis

Introduction

Background

Eutrophication condition makes several problems, i.e. bad smelt, low of transparency and dissolved oxygen, and toxic substances. Balcerzak (2006) explains that eutrophication situation makes excessive growth of phytoplankton that can absorb much DO. While, the nitrogen fixation taken from air conducted by blue-green algae can cause the bed smelt and then these conditions can reduce the ecosystem quality in reservoir water bodies and making difficulties on reservoir functions (Ling et al, 2007).

Efforts for eutrophication control have been conducted in many countries. The natural control using the predator-fish can reduce the planktons. However, the fish are difficult to survive in polluted condition (Sukimin, 2004). Chemical method had been used for eutrophication control in Wisconsin Lake, USA using flocculants substances (Gupta and Deshora, 1977). In spite of this, the flocculants has potency to be released into the ecosystem. In addition, chemical-flocculants system is only effective to apply in small reservoir and in the short term operation (Cooke and Denis, 1998). Diversion channel is applied to bypass the reservoir inflow, in order not directly discharge into reservoir other than into the retention time pond (Suxia and Boxin, 1991). Conversely, the method is high cost on construction and it has potency to spread out the water bone disease, such as *schistomiasis* etc (Ryding and Rast, 1989).

Artificial circulation is also used to prevent the reservoir stratification causing the nutrients and phytoplankton accumulation on surface layer (Hudnell et al, 2007). Nevertheless, this technology still needs

high energy for driving the system. Sediment dredging is also utilized for eutrophication control physically, but it is not effective if the sedimentation problems appeared from the reservoir catchment. Additionally, sediment dredging method is high cost in the bottom reservoir operation. Anaerobic conditions can make available as well (Cook et al, (1986).

Eutrophication control technology studied above still need energy, chemicals and high cost. With intention that, hydrodynamics behavior initiated by reservoir operation can be an alternative technology to reduce the organics and nutrients generating the eutrophication process in the reservoir. Viksburg (1995) indicates that releasing hypolimnion water can reduce the excessive phosphorous in the reservoir, so eutrophication problems can be decreased.

Based on the above background, the research objective is to apply the dynamic numerical analysis to recognize the affect of hollow jet valve (HJV) operation for eutrophication control in tropical-riverine reservoir, mainly emitted from internal pollutants load. Research hypothesis is proper and regular operation of HJV could affect the water quality improvement, therefore the hypereutrophic reservoir can be restored to be oligo-mesotrophic reservoir in the long term operation.

Reservoir Morphometry

Chapman (1996) explains that reservoirs are formed based on embankment in river flow. Chapman (1996) gives details that reservoir morphometry can be determined using Shoreline Development Index (SDI), that can be seen at eq. 1 and Table 1.

$$SDI = \frac{L}{2\sqrt{\pi * A_0}} \qquad (1)$$

SDI : Shoreline development Index

L : Length of reservoir coastal line (km)

A_o : Surface area of reservoir (km^2)

Loucks, et al (2005) classify two types of reservoir shape, i.e. regular and irregular shape. Regular shape is often called riverine reservoir, while the other is irregular shape, often called dendritic reservoir.

TABLE 1 RESERVOIR MORFOMETRI BASED ON SDI CRITERIA

Shape	SDI
Circle type	1
Rectangle 5:1 or Elliptic type	~ 1,5
Triangle 10:1 type	~ ~ ~ 2,5
Natural lake type	2 – 5
Impoundments or Riverine type	3 – 9

Ryding and Rast (1989)

Hurtado (2006) describes that riverine reservoir has three zones. The characteristics of each zone are: (1) riverine zone, i.e. low retention time, high velocity, and high nutrients concentration; (2) transition zone, i.e. lower of velocity and higher retention time compared to riverine zone; (3) lacustrine zone, i.e. low nutrient and suspended solid concentrations. Hydrodynamic conditions in riverine and transition zone are influenced by reservoir inflow. Conversely, lacustrine zone is affected by reservoir outflow. Therefore, the dynamics analysis and simulation for organics and nutrients affected by reservoir operation, including HJV, is suitable using control volume approach model respecting to the pollutant dynamics in the each of segments.

Dumitran (2008) also explains that ecosystem in lacustrine zone is affected by environmental factors, polluted load factors and polluted load came from upper zone of reservoir and then settling to lacustrine zone. Gang Ji (2008) also confirms that algae and nutrients pollutant load will concentrate to lacustrine zone in the reservoir. For this reason, the dynamic equations are focused in lacustrine zone on the reservoir.

Dynamic Analysis using WASP

Nirmalakhandan (2002) explains that dynamic systems can be relevant for investigating the environmental problems, particularly water quality problems in reservoir. WASP is the software of dynamic analysis to simulate the phenomenon of pollutant transport and transformation in the water environment and bottom sediment (Wool dkk, 2003). The software simulates the water quality in river, lake and reservoir using finite difference method to accomplish the pollutant mass equilibrium, kinetics equation and transport equation along with the simulation time. Equations of pollutant kinetics related to eutrophication process are follows: (Wool et al, 2006).

(1) Phytoplankton kinetics growth:

$$R_G = G_{\max} X_T X_L X_N \qquad (1)$$

R_G = Phytoplankton kinetics growth

G_{max} = Constants of maximum specific growth at 20^{0}C, (0.5–4.0) per day

X_T = Temperature power factor for growth (no dimension)

X_L = Light power factor for growth (no dimension)

X_N = Nutrient power factor for growth (no dimension)

(2) Influence of temperature to Phytoplankton :

$$X_T \quad = \quad \theta_G^{T-20} \qquad (2)$$

θ_G = Temperature correction factor for Growth (1.0 – 1.1)

T = Water temperature,^{0}C

(3) Influence of light intensity to Phytoplankton :

$$X_L(t) \quad = \quad \frac{e}{K_e D}\left[\exp\left\{-\frac{I_0}{I_s}\exp\left(-K_e D\right)\right\} - \exp\left\{-\frac{I_0}{I_s}\right\}\right] \qquad (3)$$

D = Mean of the depth of each segment, meter

K_e = Total light coefficient to penetrate water, per meter

I_0 = Light intensity in the surface, Langley's/day

I_s = Light saturated intensity of Phytoplankton, Langley's/day

(4) Phosphorous Cycle:

i Dissolved organics Phosphorous:

$$\frac{\partial C_8}{\partial t} \; = \; k_{diss}\theta_{diss}^{T-20} C_{15} \; - \; k_{83}\theta_{83}^{T-20}\left(\frac{C_4}{K_{mpc}+C_4}\right)C_8 \qquad (4)$$

Dissolution mineralization

ii Dissolved An organics Phosphor:

$$\frac{\partial C_3}{\partial t} = D_p\left(1 - f_{op}\right)a_{pc}C_4 + k_{83}\theta_{83}^{T-20}\frac{C_4}{K_{mpc}+C_4}C_8 - G_p C_4 a_{pc} - \frac{v_{s3}(1-f_{d3})}{D}C_3 \qquad (5)$$

Death mineralization growth settling

(5) Nitrogen Cycle:

i Ammonium (NH_3-N)

$$\frac{\partial C_1}{\partial t} \; = \; D_p\left(1 - f_{ON}\right)a_{nc}C_4 \; + \; k_{71}\theta_{71}^{T-20}\left(\frac{C_4}{k_{mpC}+C_4}\right)C_7 \; - \; k_{12}\theta_{12}^{T-20}\left(\frac{C_6}{K_{nit}+C_6}\right)C_1 \; - \; G_p\, a_{nc}\, P_{NH3}\, C_4 \qquad (6)$$

ii Nitrate (NO_3-N)

$$\frac{\partial C_2}{\partial t} = k_{12}\theta_{12}^{T-20}\left(\frac{C_6}{K_{nit}+C_6}\right)C_1 - G_p a_{nc}(1-P_{NH_3})C_4 - k_{2D}\theta_{2D}^{T-20}\left(\frac{k_{NO_3}}{k_{NO_3}+C_6}\right)C_2 \qquad (7)$$

(5) Organics (as BOD) and Dissolved Oxygen Cycle:

i Organics (as BOD):

$$\frac{\partial C_5}{\partial t} = a_{oc}k_{1d}C_4 - k_D\theta_D^{T-20}\frac{C_6}{k_{BOD}+C_6}C_5 - \frac{v_{s3}(1-f_{d5})}{D}C_5 - \frac{5}{4}\frac{32}{14}k_{2D}\theta_{2D}^{T-20}\left(\frac{k_{NO_3}}{k_{NO_3}+C_6}\right)C_2 \qquad (8)$$

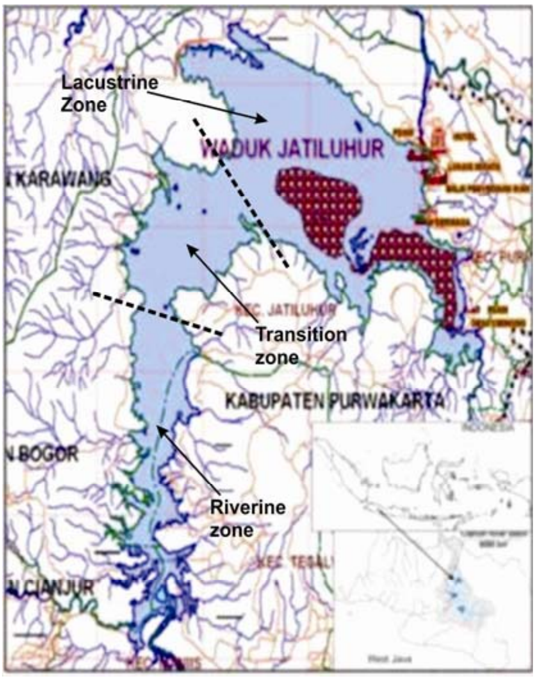
ii Dissolved Oxygen

$$\frac{\partial C_6}{\partial t} = k_2(C_s - C_6) - k_D\theta_D^{T-20}\frac{C_6}{k_{BOD}+C_6}C_5 - \frac{64}{14}k_{12}\theta_{12}^{T-20}\frac{C_6}{k_{NIT}+C_6}C_1 - \frac{SOD}{D}\theta_s^{T-20} + G_p\left(\frac{32}{12}+\frac{48}{14}a_{nc}(1-P_{NH_3})\right)C_4 - \frac{32}{12}k_{1R}\theta_{1R}^{T-20}C_4 \qquad (9)$$

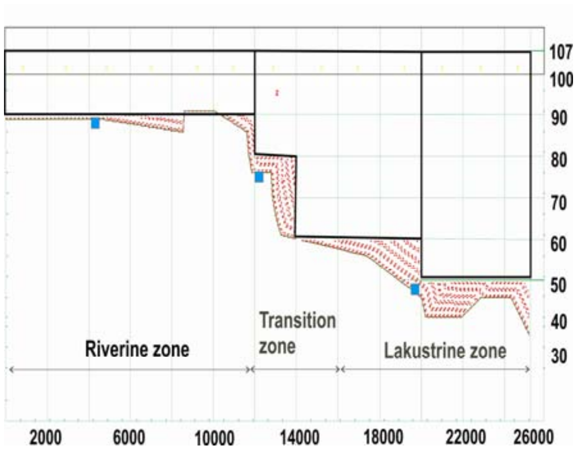
Methods

Research is carried out using Jatiluhur reservoir data that is series data on hydrometeorology and its reservoir operations. In addition, Based on SDI, Jatiluhur reservoir is categorized on riverine and eutrophic reservoir. In this research, Jatiluhur reservoir is divided on three zones, i.e. riverine, transition and lacustrine zones and 48 segments, as shown at Figure 1. Jatiluhur reservoir has three outlets systems, namely: (1) spillway (+107 m ASL); (2) the turbine intakes for electric generator (+61.7 and 75.9 m ASL), and (3) hollow jet gates for the bottom outflow (+49 m ASL). Turbine intakes and hollow jet gates are situated in the hypolimnion layer.

This research starts with the data collection i.e. bathymetric map, pollutant concentration entering to the water body. The data of the climatology and reservoir operation collected from 2001-2012 are analyzed using box plot method to determine the percentile 50 (P_{50}) or average conditions (Table 1 and 2). Figure 2 shows the flow diagram of research methodology, which analyze to DO, organics (BOD), Total Nitrogen (TN), Total Phosphorus (TP) and Chlorophyll-a.



(a)



(b)

FIGURE 1. JATILUHUR RESERVOIR AS RIVERINE RESERVOIR: (A) ITS CATCHMENT; (B) ZONATION BASED ON BATHIMETRIC MAP

The calibrations are applied on three zones of reservoir to find the optimum parameters and constants (Table 2), while dynamic analysis of the HJV influence are focused on the lacustrine zone which is directly affected by HJV operation. The simulation is performed by four scenarios, namely: (a) initial condition; (b) HJV operation; (d) integration between pollution loads reduction and HJV operation; (e) relocation effect of pollutant source.

TABLE 1 BOX PLOT ANALYSIS OF HYDRO CLIMATOLOGY DATA 2001-2012

Parameter	Units	Months											
		J	F	M	A	M	J	J	A	S	O	N	D
Rainfall	mm/d	12	16	12	8	4	2	2	2	2	6	10	10
Windflows:	m/s												
• Daylight		6	6	4	3	3	3	4	5	5	5	5	5
• Night		3	3	2	2	2	2	3	3	3	3	3	3
Sunlight	hour	3.4	3.4	3.8	5	6.5	5.2	7.2	6.4	7.2	5	3.6	3.2
Humidity	%	88.4	88.8	88.2	87.2	88	88	90	90.2	91	91.2	91.8	91.2
Temperature:	^0C												
• Min		20	20	20	20	21	21	21	20	20	20	20	20
• max		32	32	32,5	32,5	32,5	32,6	32,6	32,6	32,6	32,1	32,1	32

TABLE 2 BOX PLOT ANALYSES OF RESERVOIR OPERATIONS DATA 2001-2012

Parameter	Units	Months											
		J	F	M	A	M	J	J	A	S	O	N	D
Inflow	m^3/s	145	185	170	240	180	150	130	100	120	150	130	190
Outflow	m^3/s	140	110	100	140	185	185	160	180	170	160	160	175
Spillway	m^3/s	0	0	0	36	20	8	0	0	0	0	0	0
Turbin	m^3/s	140	110	100	115	125	150	150	160	150	150	150	150
HJV	m^3/s	0	0	0	0	18	2	18	18	2.5	4	0	0
Electric	MW	90	70	65	100	115	100	100	110	100	110	95	110

Results and Discussion

Organics and Nutrients Calibration

Calibration results for DO and BOD can be seen at Fig. 3, whereas TN and TP are shown at Fig. 4. Figure 5 illustrates calibration results for Chlorophyll-a.

Table 1 describes the calibration results for parameters and constants to analysis the affect of HJV operation for the eutrophication control. Parameter used in the dynamic analysis are atmospheric parameters, nutrients (i.e.: ammonia, nitrite, organic-nitrogen, organic-phosphorous, and ortho-phosphate), organics (as BOD), DO, light and biological factors: phytoplankton and detritus

Affect of HJV Operation and Pollutant Load Reduction

1) Dynamic Analysis of DO and BOD

Figure 6 shows that HJV operation doesn't affect to the epilimnion layer. Akkoyunlu, et al (2011) makes clear that highest production of DO is situated in the water surface, because sunlight drives photosynthesis processes. HJV operation, operated on 50 m^3/s for 24 hours once a month, can improve the DO in the middle layer from 2 mg/l to 2-3.5 mg/l after 3 years, and then it achieves to 3-8 mg/l after 8 years HJV operation. While, DO in bottom layer can improve bottom layer from anaerobic conditions to be 1.2 mg/l after 3 years and then it reaches 2.5 mg/l after 8 years HJV operation, as shown at Fig.6.

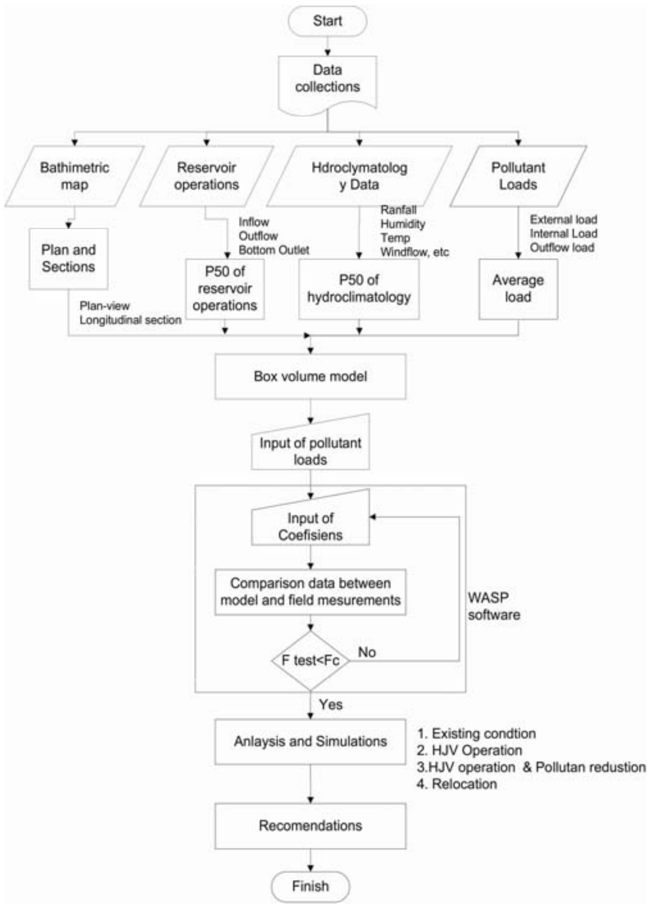
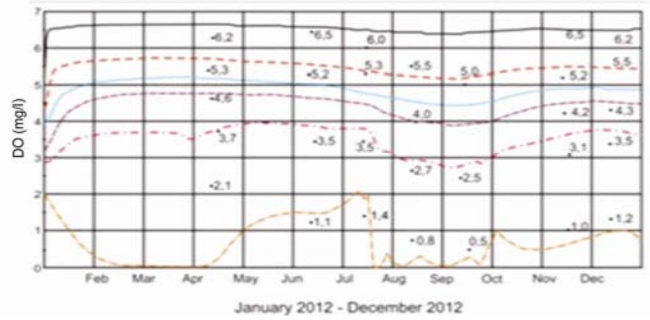
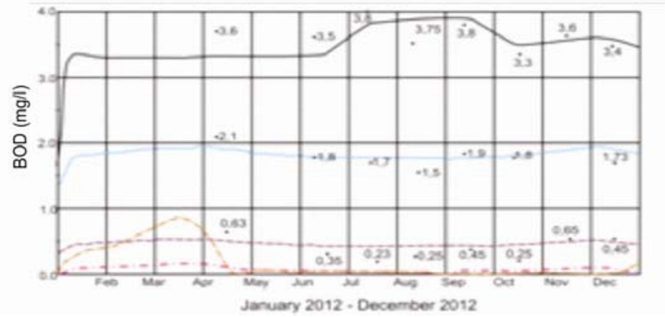


FIGURE 2. DIAGRAM OF RESEARCH METHODOLOGY

Viksburg (1995) designates that bottom withdrawal operation assists the aeration process. Xia Meng, et al (2011) also represents that HJV operations cause the hydraulics force conveying the surface layer, which is abounding of DO, contact to the bottom layer and then creating the oxygen transfer.

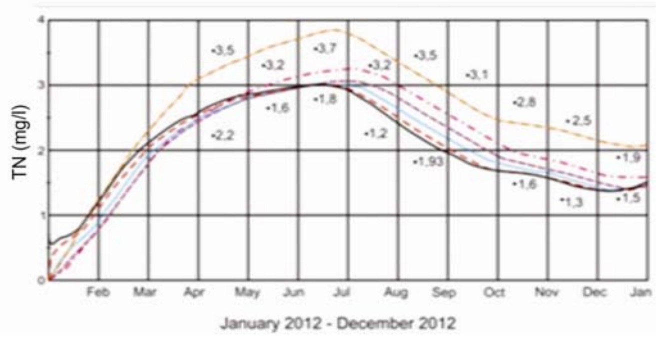


(a) DO

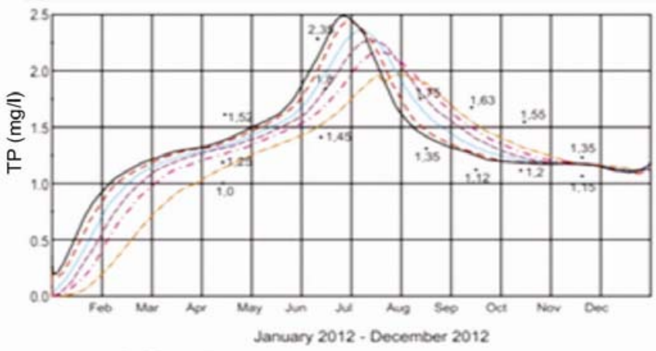


(b) BOD

FIGURE 3. CALIBRATION RESULTS OF DO AND BOD AT LACUSTRINE ZONE IN JATILUHUR RESERVOIR



(a) TN lacustrine



(b) TP at lacustrine zone

FIGURE 4. CALIBRATION RESULTS OF TN AND TP AT LACUSTRINE ZONE IN JATILUHUR RESERVOIR

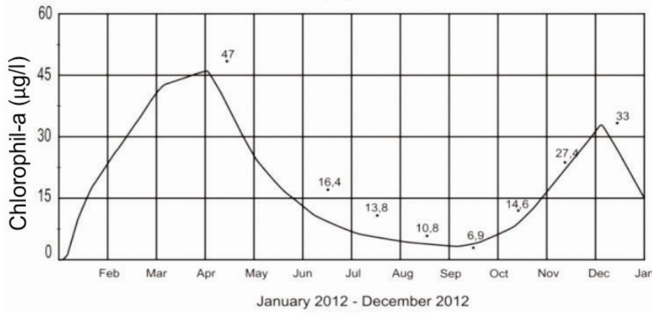
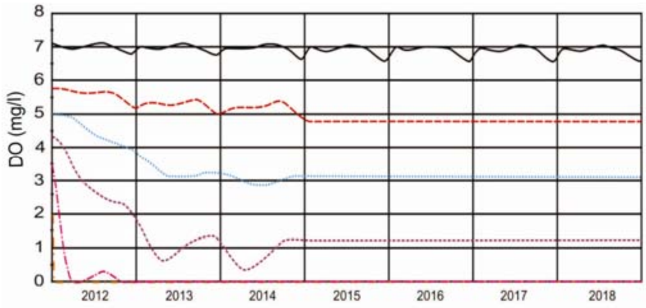
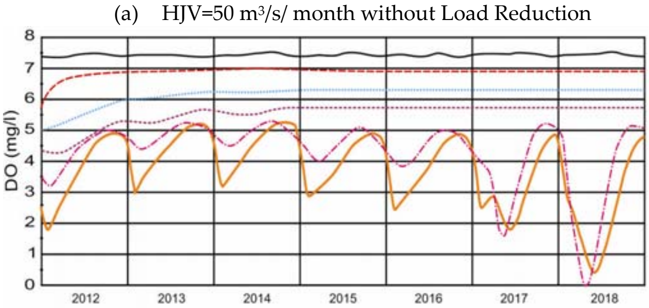


FIGURE 5. CHLOROPHIL-A CALIBRATION RESULTS AT LACUSTRINE ZONE IN JATILUHUR RESERVOIR

However, the operation doesn't attain the target, i.e. DO more than 3 mg/l. Bomin Lim, et al (2011) makes clear that DO less than 3 mg/l tend release TN and TP in sediment layer, and then triggering eutrophication process. Integration program between 50 m^3/s capacity of HJV operation (operated once a month) and 80% pollutants reduction can raise the DO from 2 mg/l to be 2,5 – 4,0 mg/l in 3 years, and then reach 6-6,5 mg/l in 8 years HJV operation. So, the ecosystem would be back to normal and eutrophication process will be reduced (Fig.6).



(a) HJV=50 m^3/s/ month without Load Reduction

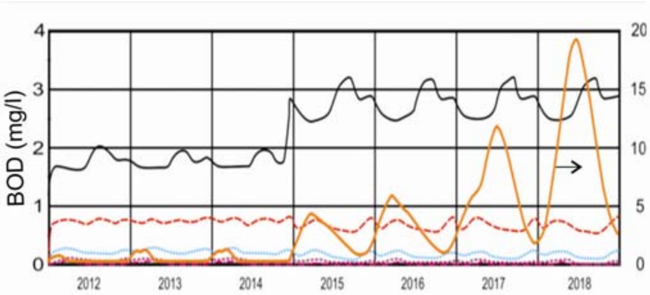


(b) HJV=50 m^3/s/month and 80% Load Reduction

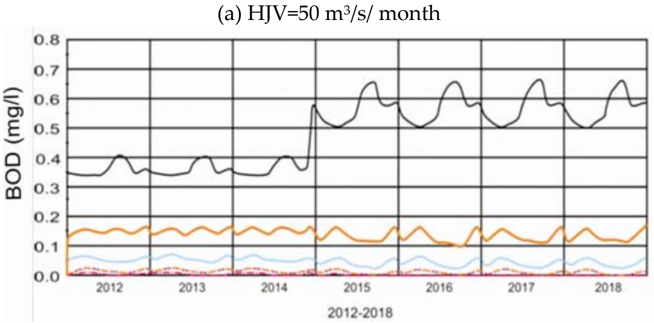
FIGURE 6 EFFECT OF HJV OPERATIONS AND POLLUTANTS LOAD REDUCTION TO DO

Based on the analysis, HJV operation of 50 m^3/s in 24 hours and once a month can reduced significantly the organics, as BOD, accumulation mainly on bottom hypolimnion layer from 3,2-10 mg/l BOD to be 1,7-2,6 mg/l BOD on 3 years, then reduced BOD accumulation until 2,8-5,2 mg/l at the end of 8 years operation.

However, the organics accumulation is still high and making DO consumed in the hypolimnion-bottom layer. So, organics reduction emitted by fish-cages cultured is needed. Integration programs between HJV operation on 50 m³/s, operated 24 hours once a month, and 80% pollutant reduction can reduce BOD, mainly in the bottom layer, from 5,2-10 mg/l reduced to 0,1-1,6 mg/l after 8 years operation, as seen at Fig.7.



(a) HJV=50 m³/s/ month



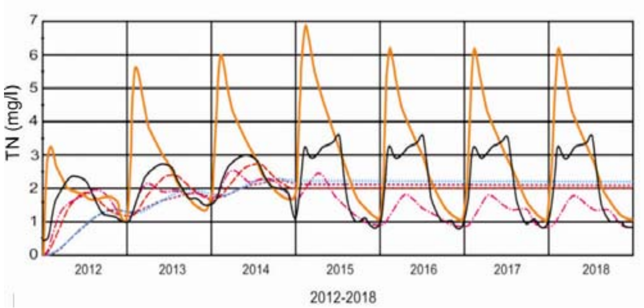
(b) HJV=50 m³/s/month and 80% Load Reduction

FIGURE 7 EFFECT OF HJV OPERATIONS AND POLLUTANTS LOAD REDUCTION ON BOD

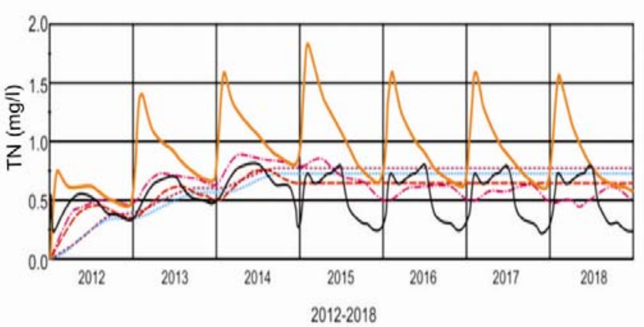
2) *Dynamics Analysis of TN and TP*

Based on the analysis, HJV operation 50m³/s, operated in 24 hours and once a month, can reduce TN in the epilimnion layer, that is from 2 mg/l to be 0,8-1,2 mg/l, while TP from 1,2 mg/l to be 0,5 mg/l in 3 years operation. Then, HJV operation can reduce both the accumulation TN and TP from 5 mg/l to be 3-3.2 mg/l of TN and 4.2 to be 3-3.2 mg/l of TP after 8 years operation, respectively, as seen at Fig.8.

Viksburg (1995) explains that HJV operation causes decrease the cycle of internal nutrients, consequently reduce the nutrients concentration in epilimnion layer. Cooke, et al (2005) also explains that reduction of nutrients concentration is comparable with TN and TP withdrawn using HJV operation. However, the operation is still not achieved with the oligo-mesotrofik target. So, integration programs both HJV operation and nutrient reduction is needed.

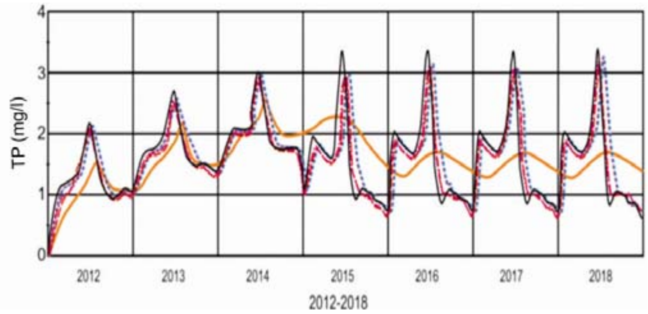


(a) HJV=50 m³/s/ month

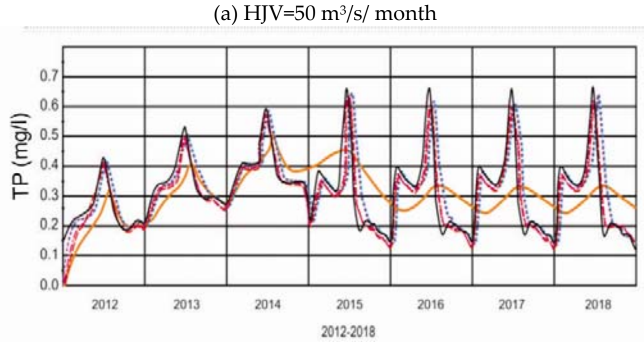


(b) HJV=50 m³/s/month and 80% Load Reduction

FIGURE 8 EFFECT OF HJV OPERATIONS AND POLLUTANTS LOAD REDUCTION TO TN



(a) HJV=50 m³/s/ month



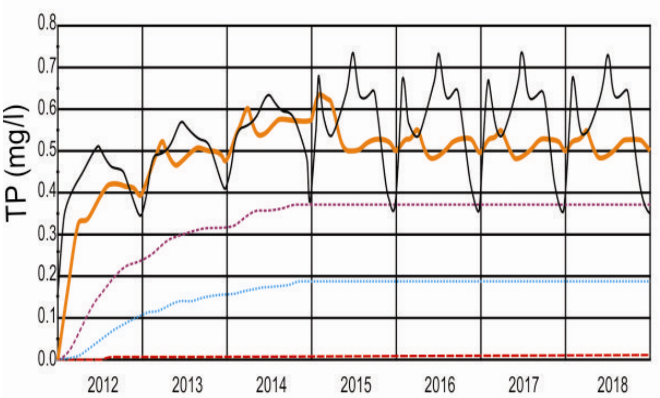
(b) HJV=50 m³/s/month and 80% Load Reduction

FIGURE 9 EFFECT OF HJV OPERATIONS AND POLLUTANTS LOAD REDUCTION TO TP

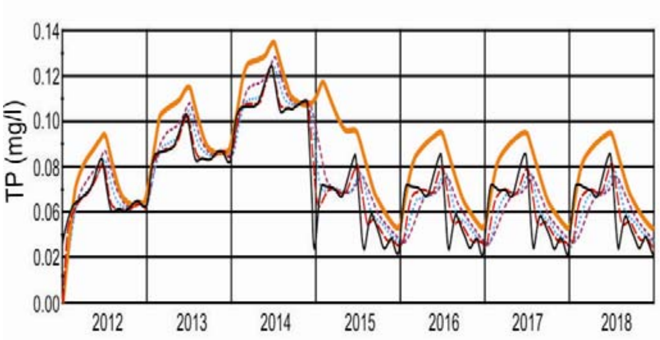
Combination HJV operation of 50 m³/s, operated 24 hours and once a month along 8 years operation, and 80% nutrients pollutant reduction can reduce the nutrients accumulation on hypolimnion-bottom layer that is TN and TP from 25 mg/l to be 1.1 mg/l of TN and from 4 mg/l to be 0.35 mg/l of TP respectively, as seen at Fig.9. In addition, the combination programs, operated once a moth along

8 years operation, also improve the water quality in both of surface and middle layer that reduced the nutrient accumulation from 5-6 mg/l to be 0.8 mg/l of TN and from 2.5-4.2 mg/l to be 0.4 mg/l of TP respectively.

The integration programs results TN concentration which is suitable with oligotrofic criteria, i.e. TN less than 1 mg/l. However, TP load emission still need to be reduced until 99% compared with the existing condition, maximum 200 fish-cage cultured, in order to attain the oligotrofic criteria, i.e. TP concentration less than 0.05 mg/l, as seen at Fig.10.



(a) 95% Reduction of Pollutant Load



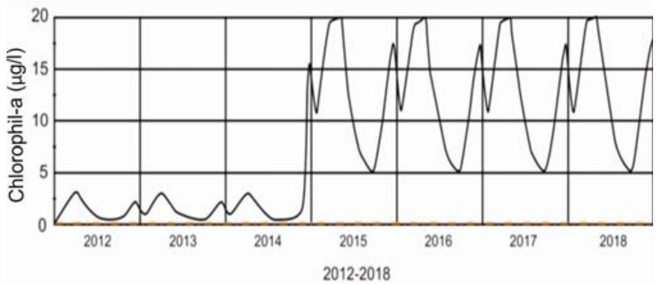
(b) 99% Reduction of Pollutant Load

FIGURE 10. EFFECT OF 50 M3/S/MONTH HJV OPERATIONS AND TP REDUCTION

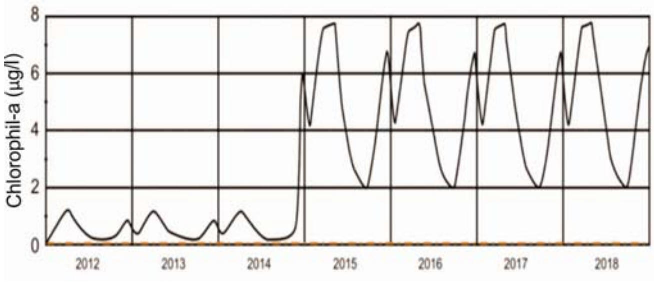
3) *Dynamics Analysis of Chlorophyll-a*

Based on dynamic analysis, HJV operation can decrease chlorophyll-a as a trofic indicator (Fig.11).

Chapman (1996) informs that turbulence condition instigated by HJV operation causes to move artificial destratification, and then phytoplankton is still in settling and suspension in bottom layer which sunlight is not enough to support the eutrophication process. Naithani et al (2007) explain that chlorophyll-a level will be reduced if the epilimnion nutrients delivered from bottom layer are decreased.



(a) HJV=50 m³/s/ months

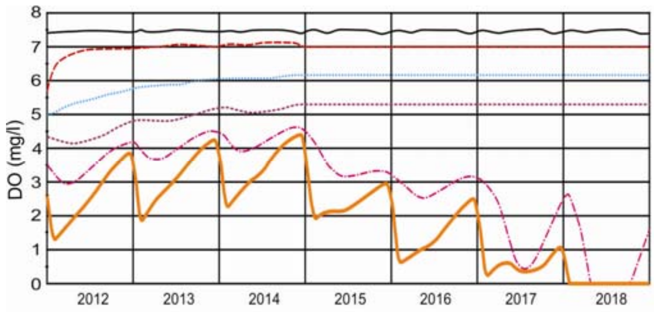


(b) HJV=50 m³/s/month and 80% Load Reduction

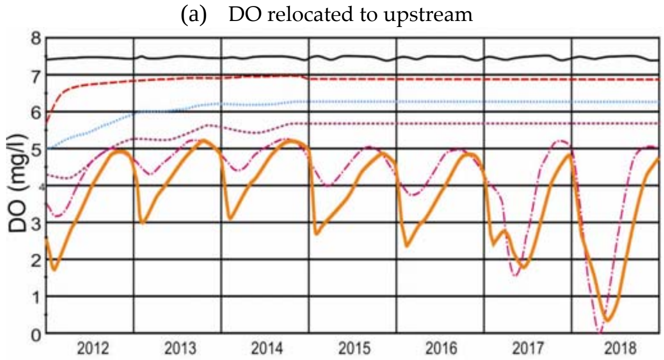
FIGURE 11. AFFECT OF HJV OPERATIONS AND POLLUTANTS LOAD REDUCTION ON CHLOROPHIL-A

Effect of the Pollutants Source Relocation

Figure 12 shows that DO level in lacustrine zone relatively more stable in 3 mg/l if the organics pollutant sources emitted by fish-cage cultured are relocated in lacustrine zone affected by HJV compared to the upstream relocation. The conditions indicate that upstream relocation tends to accumulate in the lacustrine zone.



(a) DO relocated to upstream



(b) DO relocated to lacustrine

FIGURE 13 EFFECT OF POLLUTANTS SOURCES RELOCATION TO WATER QUALITY PARAMETERS IN LACUSTRINE ZONE

TABLE 3 CALIBRATION RESULTS OF PARAMETERS AND CONSTANTS FOR DYNAMIC ANALYSIS ON EUTROPHICATION PROCESS IN JATILUHUR RESERVOIR

Global parameter			
Atmospheric Deposition of Nitrate (mg/m²-day)	0.2	Atmospheric Deposition of BOD1 (Ultimate) (mg/m²-day)	10
Atmospheric Deposition of Ammonia (mg/m²-day)	2	Atmospheric Deposition of Organic Nitrogen (mg/m²-day)	2
Atmospheric Deposition of Orthophosphate (mg/m²-day)	0.25	Atmospheric Deposition of Organic Phosphorus (mg/m²-day)	0.2
Ammonia			
Nitrification Rate Constant @20 °C (per day)	10	Minimum Temperature for Nitrification Reaction, ⁰C	10
Nitrification Temperature Coefficient	1.08	Ammonia Partition Coefficient to Water Column Solids, L/kg	1000
Half Saturation Constant for Nitrification Oxygen Limit (mg O/L)	2	Ammonia Partition Coefficient to Benthic Solids, L/kg	1000
Nitrite			
Denitrification Rate Constant @20 °C (per day)	0.09	Half Saturation Constant for Denitrification Oxygen Limit (mg O/L)	0.0005
Denitrification Temperature Coefficient	1.045		
Organic Nitrogen			
Dissolved Organic Nitrogen Mineralization Rate Constant @20 °C (per day)	1.08	Organic Nitrogen Decay in Sediment Temperature Coefficient	1.08
Dissolved Organic Nitrogen Mineralization Temperature Coefficient	1.08	Fraction of Phytoplankton Death Recycled to Organic Nitrogen	1
Organic Nitrogen Decay Rate Constant in Sediments @20 °C (per day)	0.004		
Orthophosphate			
Orthophosphate Partition Coefficient to Water Column Solids, L/kg	1	Orthophosphate Partition Coefficient to Benthic Solids, L/kg	1
Organic phosphorous			
Mineralization Rate Constant for Dissolved Organic P @20 °C (per day)	0.22	Organic Phosphorus Decay Rate Constant in Sediments @20 °C (per day)	0.0004
Dissolved Organic Phosphorus Mineralization Temperature Coefficient	1.08	Fraction of Phytoplankton Death Recycled to Organic Phosphorus	1
Organic Phosphorus Decay in Sediments Temperature Coefficient	1.08		
Phytoplankton			
Phytoplankton Self Shading Extinction (Dick Smith Formulation)	0.02	Phytoplankton Zooplankton Grazing Rate Constant (per day)	0.05
Phytoplankton Carbon to Chlorophyll Ratio	0.05	Nutrient Limitation Option	1
Phytoplankton Half-Saturation Constant for Nitrogen Uptake (mg N/L)	25	Phytoplankton Decay Rate Constant in Sediments (per day)	0.02
Phytoplankton Half-Saturation Constant for Phosphorus Uptake (mg P/L)	25	Phytoplankton Temperature Coefficient for Sediment Decay	1.08
Phytoplankton Endogenous Respiration Rate Constant @20 °C (per day)	0.125	Phytoplankton Phosphorus to Carbon Ratio	0.0025
Phytoplankton Respiration Temperature Coefficient	1.045	Phytoplankton Nitrogen to Carbon Ratio	0.45
Phytoplankton Death Rate Constant (Non-Zooplankton Predation) (per day)	0.02	Phytoplankton Half-Sat. for Recycle of Nitrogen and Phosphorus (mg Phyt C/L)	0.2
Light			
Percent Light to Define Photic Zone	0	Background Light Extinction Multiplier	1
Light Option (1 uses input light; 2 uses calculated diel light)	1	Detritus & Solids Light Extinction Multiplier	1
Phytoplankton Maximum Quantum Yield Constant	720	DOC Light Extinction Multiplier	1
Phytoplankton Optimal Light Saturation	300	DOC(1) Light Extinction Multiplier	0
Dissolved Oxygen			
Water body Type for Wind Driven Reaeration Rate	0	Minimum Reaeration Rate, per day	0
Calc Reaeration Option (0=Covar, 1=O'Connor, 2=Owens, 3=Churchill, 4=Tsivoglou) 1	1	Theta -- Reaeration Temperature Correction	1.03
Global Reaeration Rate Constant @ 20 °C (per day)	1.028	Oxygen to Carbon Stoichiometric Ratio	2.6
Elevation above Sea Level (meters) used for DO Saturation	115	Use (1 - On, 0 - Off) Total Depth of Vertical Segments in Reaeration Calculation	1
Reaeration Option (Sums Wind and Hydraulic Ka)	0		
Detritus			
Detritus Dissolution Rate (1/day)	0.01	Temperature Correction for detritus dissolution	0

Conclusions

Based on dynamic numerical analysis using box volume model applied in Jatiluhur reservoir is achieved the conclusions as follows:

a. Regular operation of HJV, operated once a month on 50 m^3/s in capacity and carried out more than 8 years operation, can improve the water quality parameters in the reservoir that is reduction of TN and TP initiating eutrophication process, and reduction the organics, as BOD and then increase the DO as an indicator of ecosystem improvement.

b. Integration program between HJV operation, 50 m^3/s in capacity and carried out more than 8 years operation, and pollutant reduction until more than 80% compared to the existing conditions can improve the effectiveness of eutrophication control program, particularly on fish-cage cultured reduction program, i.e. less than 2400 maximum of fish-cage cultured

c. The programs of HJV operation and pollutant reduction can renovate the eutrophication statues from eutrof-hipereutrofik to be oligo-mesotrofik, that is DO more than 3 mg/l, BOD less than 1 mg/l, and TN achieves less than 1 mg/l. While, attaining TP less than 0.02 mg/l, internal pollutants should be reduced until 99% compared with existing conditions.

d. After reduction program, the remaining of fish-cage cultured should be relocated in the lacustrine zone which is affected by the stream of HJV outflow, compared with the upstream relocation. Because, the pollutant emissions relocated to the upstream in riverine zone can accumulate to the lacustrine zone in the long time.

e. Dynamic analysis can simulate the water quality behavior in the tropical-riverine reservoir. The results can also optimize the integration between HJV operation and pollutant reduction programs to achieve the oligotrofic level on Jatiluhur tropical-riverine reservoir.

ACKNOWLEDGMENT

The authors would like to thanks to Mr. Bambang Hargono, Director of the Research and Development Institute for Water Resources (RDIWR) Indonesia, for all the support and also to my colleagues from Water Environment Laboratory of RDIWR to support the materials and data in making the research success.

REFERENCES

Akkoyunlu, A., Altun, H.Cigizoglu, H.K.2011. Depth Integrated Estimation of DO in a Lake. *J Env.Eng*. 137 (10). ASCE, pp: 961-967.

Balcerzak, W. 2006. The Protection of Reservoir Water against the Eutrophication Process, Institute of Water Supply and Environmental Protection, Kraków University of Technology, Warszawska 24, 31-155 Kraków, Poland, *Polish Jurnal of Environment Study*, 15 (6), pp 837-844.

Bomin Lim, Bomin Ki, and Jung Hyun Choi. 2011. Evaluation of Nutrient Release from Sediments of Artificial Lake. *J.Env.Eng*. 137(5). ASCE.

Chapman, D (Editor). 1996. *Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring*. Second Edition. UNESCO/WHO/UNEP, ISBN 0 419 21590 5.

Cooke, G.D., R.T. Heath, R.H. Kennedy, and M.R. Mc Comas. 1978. Effects of Diversion and Alum Application on Two Eutrophic Lakes. EPA-600/3-81-012.

Cooke and Dennis G. 1993. Restoration and Management of Lakes and Reservoirs, Second Edition. Lewis Publishers.

Dumitran,G.E. 2008. Bradisor Lake Restoration Affect to Eutrophication Process. *UPB Science Bulletin Series D*, 70(4), Bucharest, Romania.

Gang Ji, Zhen.2008 *Hydrodynamics and Water Quality: Modelling Rivers, Lake, and Estuaries*. John Willey & Sons,Inc. New Jersey, Canada.

Gupta, R.S. and Deshora, H.S., 1977. Drinking Water Quality Enhancement through Source Protection: Algal Pollutants and Potable Water. Editor: Pojasek, R.B., ISBN: 0-250-40388-6. Ann Arbor Science Publisher.Inc, Michigan-USA, pp: 431-444.

Hoybye, J., Iritz,L., Zhlesnyak., Maderich., V., Demchenko, Dzuba,N., Donchitz,G., Kosebutsky, V. 2002. Water Quality Modeling to Support the Operation of the Kakovska Reservoir, Dnieper River, Ukraine. *Proceeding of the fifth International Conference on Hydro informatics*, Cardiff, UK, IWA Publishing.

Hudnell, K., Hansen, C.K., Pattarkine, VM. 2007. Approaches to freshwater HAB control sustainable lake water quality restoration by inhibiting harmful algal blooms using solar-powered technology.

Hurtado, J.V .2006. *Basin Scale Hydrodynamic in a Mediterranean Reservoir Implications for the Phytoplankton Ddynamics*. PhD Dissertation University of Girona, Spain.

Ling, D., Wu, J. Q., Pang, Y., Li, L., Gao, G., & Hu, D. W. 2007. Simulation study on algal dynamics based on ecological flume experiment in Taihu Lake,China. *Ecological Engineering , 31*, 200-206. Elsevier.200-206.

Loucks, D.P.,Van Beek, E., Stedinger, J.R., Dijkman, J. M., Monique T. 2005. *Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications* UNESCO, Paris.

Naithani, Darchambeau, Deleerrnijder, Descy and Wolansky. 2007. Study of the Nutrient and Plankton Dynamics in Lake Tanganyika using a Reduced-Gravity Model. *Ecological Modeling* (200). Elsevier Science, pp: 225-232.

Ryding dan Rast. 1989. *The Control of Eutrophication of Lakes and Reservoir*. The Parthenon Publishing Group, New York.

Sukimin. 2004. Pengelolaan Waduk Kaskade Sungai Citarum: Tinjauan Aspek Ekologi Perairan. *Seminar Pengelolaan Waduk dan Danau*, 13 Oktober 2004, Puslitbang Sumber Daya Air, Bandung.

Viksburg, MS.1995. *The WES Handbook on Water Quality Enhancement Technique for Reservoirs and Tail waters*. In cooperation: US Army Corp of Engineers and US EPA.

Wool, A.T., Ambrose,R.B., Martin,L.J., dan E.Corner.2006. *User's Manual:Water Quality Analysis Smulation Program (WASP) version 6*. US EPA, Atlanta.

Xia, Meng., Craig,M.P., Schaefer,B., Stoddard,A. Liu,Zhijun., Peng,Machuan. 2010. Influence of Phisical Forcing on Bottom Water Dissolved Oxygen Within Caloosahtze River Estuary. *J Env.Eng*, 136(10), ASCE.

Eko Winar Irianto, Bachelor on Environmental Engineering, Institute Technology of Bandung. Master on Environmental Engineering, ITB, Bandung. PhD student on Water Resources Engineering, Parahyangan Catholic University, Bandung, Indonesia. Interest on water quality modeling.

Prof. Robertus Wahyudi Triweko, PhD. Professor on Water Resources Engineering, Parahyangan Catholic University, Bandung, Indonesia. MEng. at Hydraulics and Coastal Engineering, Asian Institute of Technology, Bangkok, Thailand. PhD on Colorado State University, USA.

Priana Sudjono, **PhD.** Associate Professor at School of Environmental Engineering, Institute of Technology (ITB), Bandung, Indonesia. Graduated Ph.D from Environmental Engineering, Saga University, Japan. Member of. Indonesian Society of Sanitary and Environmental Engineering.